from separate testing sessions completed within and between test days (reproducibility) would be ≤ 5%.

Methods: Three-dimensional kinematics and kinetics collected from 166 patients with medial compartment knee osteoarthritis before and after high tibial osteotomy were used to identify representative values for the frontal plane lever arm about the tibiofemoral joint, ground reaction force, and tibiofemoral angles. A fixture was designed and fabricated based on these data and used in a materials testing machine with a pressure measurement system to quantify the distribution of applied loads between medial and lateral contact surfaces of proximal tibia and distal femur sawbones.

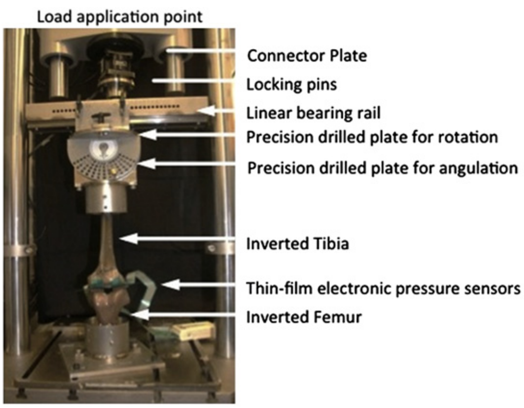

Figure 1. Photograph of inverted tibia and femur sawbones mounted in the fixture designed to position and load the lower limb based on 3D gait kinematic and kinetic gait data. A stainless steel plate connected the multi-axis fixture to the actuator of the materials testing machine. With reference to the anatomical planes of motion, the capability to translate the fixture horizontally along a linear bearing rail in 1 cm increments (+/-10 cm) mimicked the frontal plane level arm about the tibiofemoral joint. A precision-drilled stainless steel plate with a series of holes provided the capability to rotate the inverted tibia to alter varus/valgus angulation in half-degree increments (+/- 35 degrees). A second plate enabled internal/external rotation in 5-degree increments (+/- 15 degrees). The tibia and femur were potted and aligned to create 15 degrees of flexion. All positions were held with locking pins and bolts. Pressure distribution between medial and lateral contact surfaces of the proximal tibia and distal femur was measured with thin-film electronic pressure sensors while a load of 900 N was applied by the materials testing machine.

First, the change in distribution of medial-lateral compartment loads was evaluated using three lever arms, the corresponding angles between the tibia and GRF, and a compressive force of 900N (the approximate mean frontal plane GRF from the *in vivo* gait data). Then, reliability of load distribution was tested by repeating measurements using a 3cm lever arm (the mean frontal plane lever arm from the in vivo data 24 months post-surgery).

Results: The change in distribution of loads using lever arms of 1, 3 and 5cm, ranged from approximately 40-to-85%. The load on the medial side was 70.1%, when using a representative lever arm of 3cm. Coefficients of variation for repeated measures ranged from 0.66%-to-1.83% for trials within one test session, was 2.70% for trials between test sessions within one day, and was 4.88% for trials between days.

Conclusions: Results demonstrate appropriate asymmetric loading and excellent test-retest reliability. These findings suggest the fixture enables loading of the lower limb in a manner more representative of walking and will be used for future materials testing of HTO plate designs.

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INERTIAL SENSOR BASED GAIT ANALYSIS: A CLINICAL APPLICATION IN PATIENTS WITH OSTEOARTHRITIS

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Purpose: Commonly used patient reported outcome scores demonstrate poor/moderate correlations with objective performance-based measures such as gait analysis. Recent advances in miniaturization and cost of ambulatory motion sensors has made accelerometer based gait analysis (AGA) suitable for clinical research. The use of gyroscopes in conjunction with accelerometers (i.e. inertial sensors), enables the assessment of position and angular movements of body segments and provides ambulatory kinematic characterization of gait. We investigated commonly used gait parameters and whether they correlate with patient reported and surgeon reported outcome scores.

Methods: Gait was studied in healthy subjects (n=20), in patients with end stage hip OA (n=20) and in patients with end stage knee OA (n=20). Subjects walked 20 meters in an indoor environment along a straight flat corridor at their own preferred speed. A 3D inertial sensor was positioned centrally between the posterior superior iliac spines (PSIS) overlying S1.

Results: Comparing gait parameters of end stage hip OA patients with an age and gender matched healthy control group, significantly lower walking speed, longer step duration and shorter step length was observed. There was a significant difference in walking time between end stage hip OA patients (seconds 18.7 +/- 3.8) and healthy subjects (15.6 +/- 1.7) ($p<0.05$) and end stage knee OA patients (21.2 seconds =/- 4.7) ($p<0.05$) and healthy subjects. There was no significant difference between the walking time between hip and knee OA patients. However, after correcting for walking speed between groups, significantly less average range of motion of Pelvic Obliquity (RoMpo) was observed for patients with end stage hip OA (5.5 +/-1.4) compared to healthy subjects (6.7 +/- 1.9) and patients with end stage knee OA (7.03 +/- 1.9).

Patients with end stage hip OA in this study demonstrated a mean Harris Hip Score (HHS) of 66.7 ±15.7. Pearson's correlation coefficients between HHS and gait parameters ranged from 0.18 to 0.40. Hip OA patients showed a mean WOMAC Hip score of 58.9 ±19.2. Patients with end stage knee OA showed a mean WOMAC Knee score of 51.5 ±12.4. WOMAC scores in knee OA patients were moderately-well correlated to speed, cadence and step time: r= 0.53; 0.51; -0.48; respectively ($p<0.05$). Furthermore, knee OA patients demonstrated a mean American Knee Society Score (AKSS) of 51.9 ±11.5 with no correlations to gait parameters.

Conclusions: Gait parameters were different between those with end stage OA of either the knee or hip from healthy subjects. The Pelvic obliquity range of motion was significantly decreased in patients with Hip OA while timed parameters did not differentiate between the groups.

AGA detects disease dependent functional limitations which can be used for longitudinal follow-up. As gait parameters only moderately correlated with classic outcome scores, AGA may measure another dimension of physical function and could be used measure recovery of OA patients before and after joint replacement.

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COMPARISON OF IN VIVO KINEMATICS OF THE KNEE BETWEEN GAIT AND SQUAT

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Purpose: Gait kinematics provide important information to understand the load on the articular surface because gait is the most common activity in daily life, and produces a cyclically reproducible pattern of loading.

While a number of studies investigated the knee kinematics during squat which shows medial pivot pattern, kinematics during gait is not well studied, nor compared with that during squat.

The purpose of this study was to compare in vivo kinematics during gait and squat in the normal knee, specifically focusing on the tibiofemoral axial rotation and contact location of the articular surface.

Methods: Ten subjects without a history of injury in the lower extremity were enrolled in this IRB approved study. There are 5 females and 5 males, the average age was 26.9 years.

Lateral fluoroscopic images of the left knee during gait and squat were recorded. For gait, subjects walked on a treadmill at 1m/sec, and images of the whole gait cycle from heel strike to the next heel strike were recorded at 60 frames/sec. For squat, activity from full extension to maximal flexion was performed in 2 seconds, and was recorded at 10 frames/sec. Subjects also underwent CT scanning with a 1.0mm slice pitch spanning 150mm above and below the knee joint line. Three-dimensional bone models of